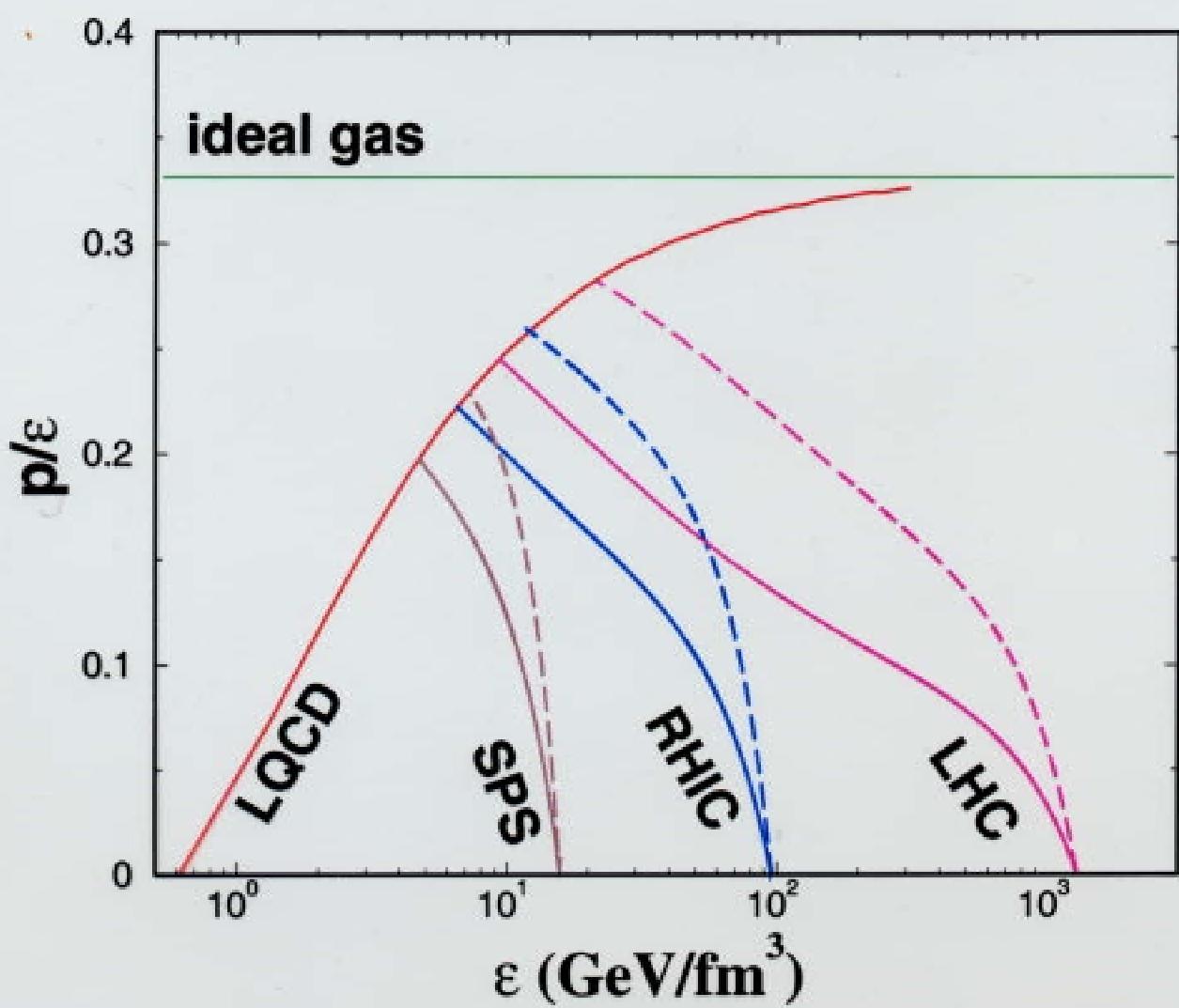


# Degrees of Freedom and the "Deconfining Phase Transition"

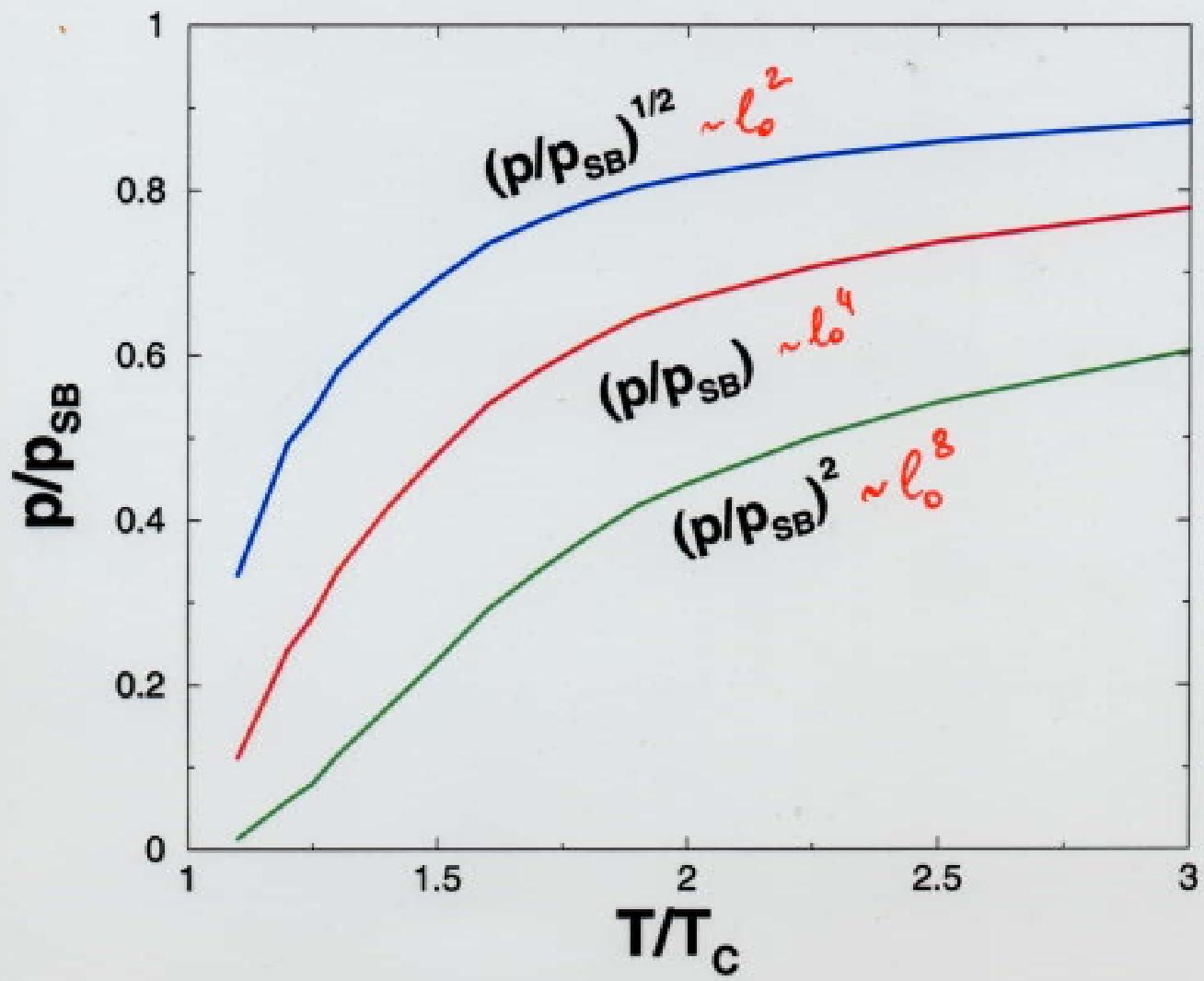
A.D. + Rob Pisarski  
hep-ph/0106176

- A fundamental prediction from the Lattice:  
for 3 colors, QCD or  $SU(3)$  gauge theory  
is not an ideal gas for  $T/T_c \sim 1-3$ .  
 $P_{QCD}(T) \neq P_{SB}(T)$
- Can it be seen from HIC @ RHIC??  
Observables ...  
(HBT ( $\pi, K$ ): strong 1st- $O$  p.t. ??)  
(flow analysis: Teaney + Shuryak)  
Energy loss  
Continuum Dileptons + Photons  
⋮  
Parton Cascade Scattering Rates

A.D. + Miklos Gyulassy  
hep-ph/0006257



pressure for  $SU(3)$  LGT  
CP-PACS, hep-lat/0105012



$$N_f = 0 \longrightarrow N_f > 0$$

$T_c$  changes:  $0.63\sqrt{\sigma(0)} \rightarrow 0.41\sqrt{\sigma(0)}$

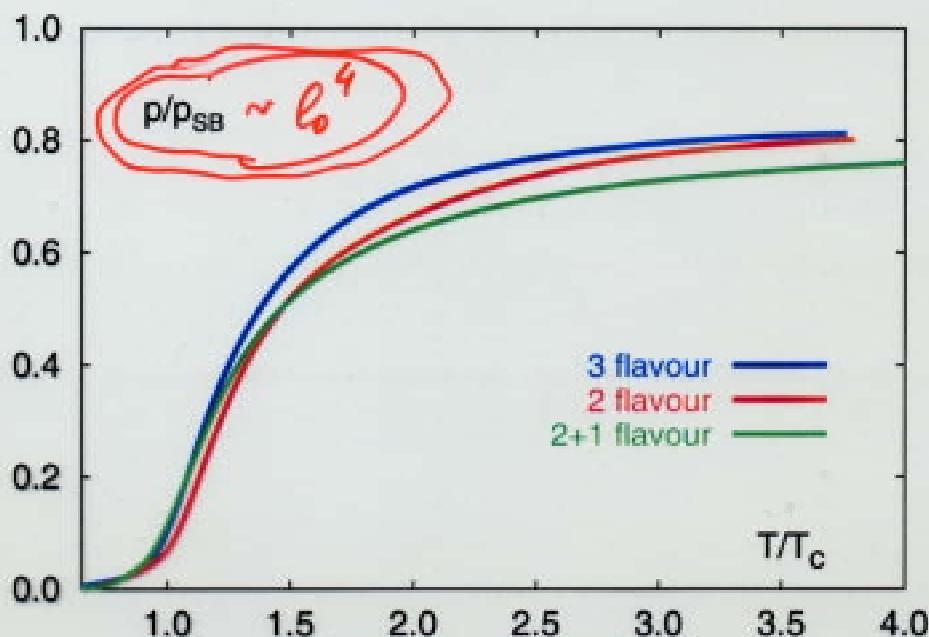
$P_{SB}/T^4$  changes:  $\frac{16\pi^2}{90} \rightarrow \frac{37\pi^2}{90} (N_f=2), \frac{47.5\pi^2}{90} (N_f=2+1)$

but

$$P(T/T_c) / P_{SB} \approx \text{universal}$$

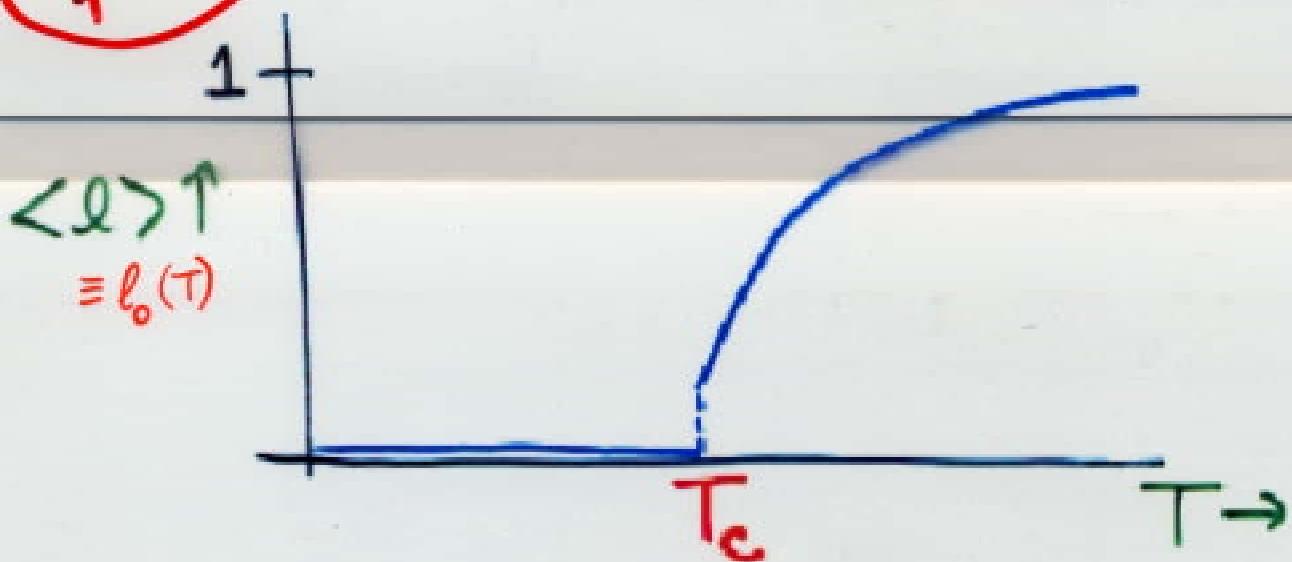
and

$P \approx 0$  for  $T < T_c$



Karsch, Laermann, Peikert  
hep-lat/0002003

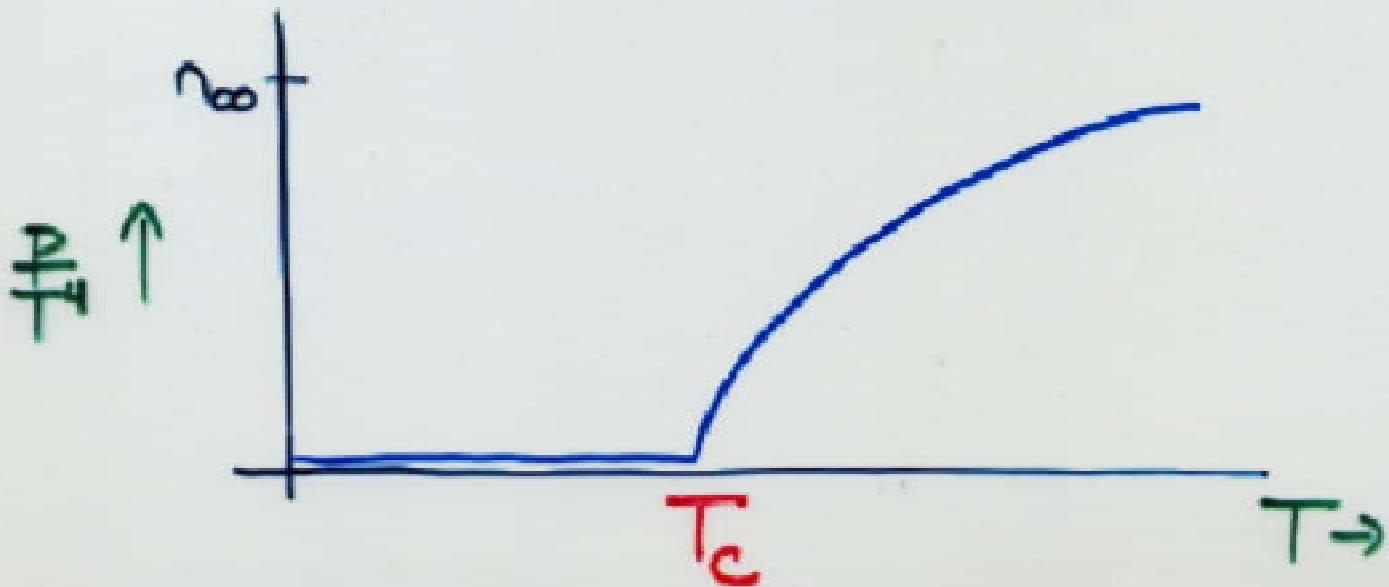
$N_f=0$  Polyakov Loops & pressure



$$V = (2b_2 |l|^2 + |l|^4) b_4 T^4$$

$l$  dim. less  $\Rightarrow$  overall  $T^4$ !

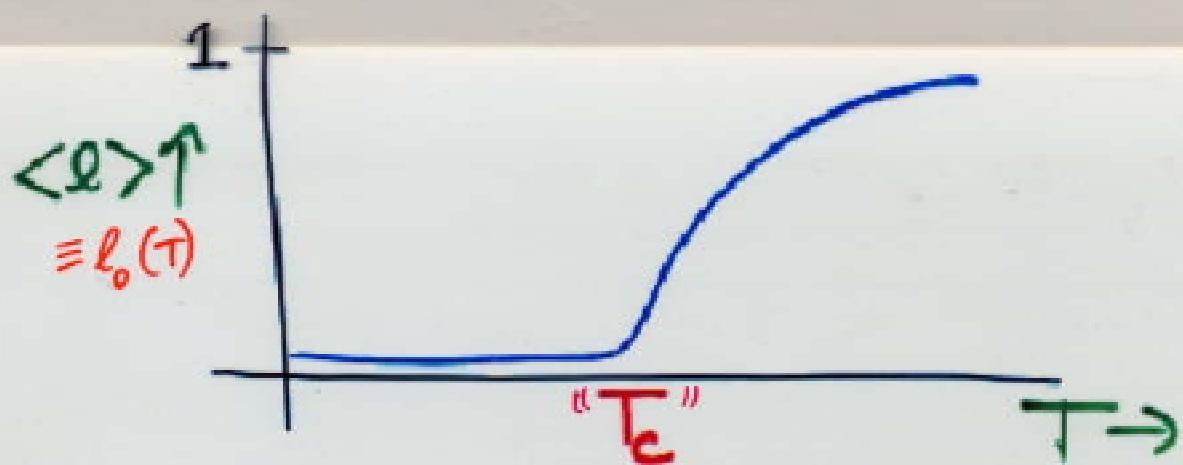
+  $b_3 (l^3 + \frac{1}{l})$  nearly 2<sup>nd</sup> order  $\Rightarrow b_3$  small



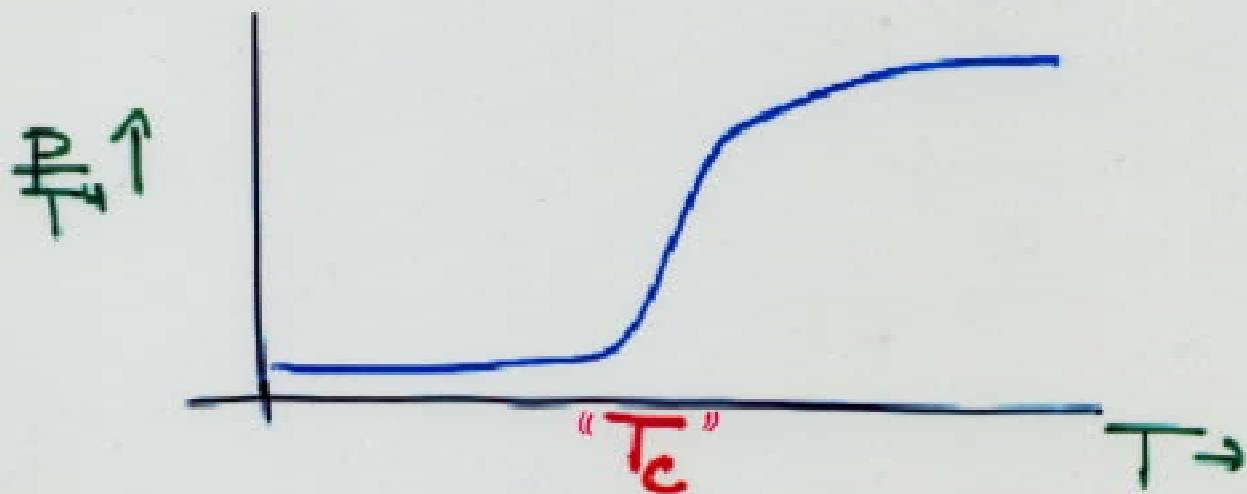
Rob Pisarski, PRD 62 (2000)

$$N_f \neq 0$$

$$\langle \ell \rangle \neq 0 \quad \forall T$$



$$V = (b_1(\ell) + 2b_2|\ell|^2 + (|\ell|^2)^2)b_4 T^4 + \ell^3 \dots$$



$p$  small @  $T < T_c \Rightarrow p$  dominated by  $V(\ell)$

{ increases by - ? - 5 as  $T \rightarrow T_c$

## Radiative Energy Loss:



$$E_{LPM} = \lambda m_e^2$$

$$m_e^2 = V''(l_0) \sim l_0^{-2}$$

$$1) \frac{E}{E_{LPM}} < N^2 : - \frac{dE}{dz} \sim \frac{\alpha_s}{\pi} \frac{E}{\lambda} \sim l_0^{-2}$$

$$2) \frac{E}{E_{LPM}} > N^2 : - \frac{dE}{dz} \sim \frac{\alpha_s}{\pi} m_e^2 \frac{L}{\lambda} \sim l_0^{-4}$$

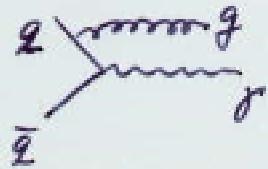
## Continuum "Thermal" Dileptons:

$$\frac{dN^{\tau^+ \tau^-}}{d^4x} \sim \left( \frac{P_{QCD}}{P_{SB}} \right)^2 \sim l_0^{-8}$$



## ... Photons:

$$\frac{dN^\gamma}{d^4x} \sim \left( \frac{P_{QCD}}{P_{SB}} \right)^{3/2} \sim l_0^{-6} (?)$$



# Is Energy Loss proportional to Energy Density?



→ Is there a non linear dependence of E-loss on  $E_L$ ??  
Is it proportional to  $\sqrt{\frac{P_{QCD}}{P_{SB}}}$  ?????  
from the Lattice with 3 colors

There might be a transition from

$$E\text{-loss} \sim \sqrt{E_L}$$

(similar to Bjorken '82 prediction for elastic E-loss)

to

$$E\text{-loss} \sim E_L$$

(Stefan - Boltzmann QGP)  
Gyulassy / Vitev et al.

BDNPS

Wiedemann

Zakharov

:

Transport Opacity  $\chi \sim \sigma_t \frac{dN}{dy}$

Transport X section  $\sigma_t \sim \frac{\alpha^2}{s} \log \frac{s}{m_e^2}$  (for  $\frac{m_e^2}{s} \sim 1$ )

Extreme Perturbative QGP:  $m_e = 2 m_{D\bar{D}} \sim \sqrt{\alpha T}$

but smaller at  $T/T_c = 1 \dots 3$ !

As before,  $\frac{dN}{dy} \sim \ell_0^{-4}$

mass of Polyakov Loop  $m_e^2 \sim \ell_0^{-2}$

## MPC v2, Denes Molnar

nucl-th/0104073

